

TITLE OF THE INVENTION

AREA SENSOR, IMAGE INPUT APPARATUS HAVING THE SAME, AND
METHOD OF DRIVING THE AREA SENSOR

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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to area sensors for use
10 in digital cameras, X-ray photographing apparatuses, etc.,
relates to image input apparatuses, such as digital cameras
and X-ray photographing apparatuses having area sensors, and
relates to methods for driving the area sensors. More
particularly, in an area sensor in which pixels having
15 photoelectric conversion elements and switching elements are
arrayed two-dimensionally, the present invention relates to
an area sensor in which a driving signal for driving each
pixel is applied from opposing two sides, relates to an
image input apparatus having the area sensor, and relates to
20 a method of driving the area sensor.

Description of the Related Art

An example of an area sensor in which pixels having
photoelectric conversion elements and switching elements are
arrayed two-dimensionally is described with reference to
25 Figs. 1, 2A, 2B, 2C, and 3.

Fig. 1 is a schematic circuit diagram of an example of an area sensor having photoelectric conversion elements and switching elements in pixels. Fig. 2A is an equivalent circuit diagram of a gate line of an area sensor. Figs. 2B 5 and 2C are diagrams illustrating the status of a driving waveform applied to the gate line from a gate driver. Also, Figs. 2B and 2C are conceptual diagrams illustrating the shape of a driving waveform (gate pulse) at point A and point B, respectively, in Figs. 1 and 2A. Fig. 3 is a timing chart illustrating an example of the driving of the 10 gate driver in the area sensor.

Each pixel S of the area sensor shown in Fig. 1 is formed of a photoelectric conversion element (herein, a photodiode) PD and a thin-film transistor (TFT) Tr. The cathode electrode of the photodiode PD is connected to a bias line Vs, and a bias voltage is applied by a power supply 3. The source electrodes of the thin-film transistors Tr are connected to the data lines Sig1 to SigN for each pixel column, and the gate electrodes of the thin-film transistors Tr are connected to the gate lines Vg1 to VgN for each pixel row. In this example, wiring necessary for driving the area sensor is the bias line Vs, the data lines Sig1 to SigN, and the gate lines Vg1 to VgN. Furthermore, the anode electrodes of the photodiodes PD and 25 the drain electrodes of the thin-film transistors Tr are

connected to each other by pixels. In this example, the data lines Sig₁ to Sig_N are arranged in the vertical direction in Fig. 1, and the gate lines Vg₁ to Vg_N are arranged in the horizontal direction. In addition, each of
5 the data lines Sig₁ to Sig_N is connected to a reading apparatus 1. Generally, the reading apparatus 1 comprises an amplifier 1a to which each of the data lines Sig₁ to Sig_N is connected, and an analog multiplexer 1b to which a signal from each amplifier 1a is input. On the other hand, each of
10 the gate lines Vg₁ to Vg_N is connected to a gate driver 2. Generally, the gate driver 2 comprises a shift register.
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Image information which is photoelectrically converted by each pixel is transferred to the reading apparatus 1 through the data lines Sig₁ to Sig_N, and is output as a serial signal for each gate line.

In the area sensor, the gate driver and the reading apparatus are connected to each other only at one side of a rectangular area which is an image receiving area in which pixels are arrayed. However, the area sensor having such a
20 connection relationship has a problem in that, in a case where a disconnection occurs in the gate line or the data line, the driving of pixels in a portion after the disconnection and the transfer of a signal from the pixels cannot be performed.

25 Also, even when a disconnection has not occurred, the

gate line of the area sensor includes a resistor. In particular, when the image receiving area is enlarged, or when the pixels are arranged in finer lines and the gate line width is reduced, cases occur in which the resistance 5 cannot be substantially ignored. The gate line of the area sensor can be expressed by a resistor R_{vg} of the gate line itself and a parasitic capacitor C_{vg} of the gate line, as in Fig. 2A, from a point of view of an equivalent circuit. Therefore, in the gate pulse (see Fig. 2B) which is applied 10 to "A" of the gate line V_{gN} in Fig. 1, a delay occurs in the signal at "B" of the gate line V_{gN} due to the resistor R_{vg} and the parasitic capacitor C_{vg} , the waveform is deformed as shown in Fig. 2C, and a wavelength width in a portion exceeding a threshold voltage V_{th} is varied. Generally, in 15 order to turn on a TFT and to transfer electric charge, it is necessary for the time period during which a voltage exceeding the threshold voltage V_{th} to be a time period T_b or more. When such a delay of a waveform as that described herein occurs, since the time period in which this threshold 20 voltage V_{th} is exceeded becomes short, the time period T_a of the original pulse width must be set to be long so as to secure the time period T_b required for transferring electric charge.

As shown in the driving timing chart of Fig. 3, in 25 order to drive the entirety of the area sensor, due to this

delay, a time period becomes necessary which is extended by an amount corresponding to $(Ta - Tb) \times N$ (N is the number of lines). There are cases in which this becomes an obstacle to driving the area sensor at an even higher speed.

5 As described above, the area sensor could be further improved in view of the fact that the driving of pixels in a portion after a disconnection and the transfer of a signal from the pixels cannot be performed and in order to perform high-speed driving.

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SUMMARY OF THE INVENTION

The present invention has been achieved in view of the above-described problems in the area sensor. An object of the present invention is to provide an area sensor in which there is no effect due to disconnections and which is suitable for high-speed driving, to provide an image input apparatus having the area sensor, and to provide a method of driving the area sensor.

15 Another object of the present invention is to provide a highly reliable area sensor in which there is no defective driving such as that which occurs due to a disconnection of wiring which crosses an image receiving area such as gate lines and data lines, and in which there is no impairment such as inability to obtain data, and in which image information can be output stably, to provide an image input

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apparatus having the area sensor, and to provide a method of driving the area sensor.

Another object of the present invention is to provide an area sensor which is capable of supplying a desired 5 driving waveform, which can be driven at high speed, and as a result which is suitable for obtaining a moving image, to provide an image input apparatus having the area sensor, and to provide a method of driving the area sensor.

Another object of the present invention is to reduce 10 random noise arising from the wiring resistance of the gate line and to realize a higher S/N ratio.

Another object of the present invention is to provide an area sensor having an image receiving area which is larger, an image input apparatus having the area sensor, and a method of driving the area sensor, and to provide an area 15 sensor, in which a driving speed is not decreased due to the larger area, or in which driving speed can be improved, the decrease in the driving speed being minimized in comparison with a case in which area sensors having an image receiving section of a small area are combined, and higher definition reading and display being made possible, to provide an image 20 input apparatus having the area sensor, and to provide a method of driving the area sensor.

To achieve the above-mentioned objects, in a first 25 aspect, the present invention provides an area sensor

comprising: plural pixels, each having a switching element,
arranged two-dimensionally, and plural common lines which
are connected to the switching elements corresponding to the
pixels which are arrayed in a direction, a control signal
5 being applied to the common line in order to drive the
switching element, wherein plural driving means for applying
the control signal are connected to the common lines.

In a second aspect, the present invention provides an
area sensor comprising: plural pixels, each having a thin-
film transistor and a photoelectric conversion element,
arranged two-dimensionally, and plural common source lines
which are connected to the source electrodes of the thin-
film transistors which are arrayed in a direction, wherein
plural signal reading means are connected to the common
15 source lines.

In a third aspect, the present invention provides an
area sensor comprising: plural pixels, each having a thin-
film transistor and a photoelectric conversion element,
arranged two-dimensionally, plural common gate lines which
20 are connected to the gate electrodes of the thin-film
transistors which are arrayed in a direction, and plural
common lines which are connected to the source or drain
electrodes of the thin-film transistors which are arrayed in
another direction, wherein plural signal reading means are
25 connected to the common lines, and plural gate driving means

are connected to the common gate lines.

In a fourth aspect, the present invention provides a method of driving an area sensor having plural pixels, each having a switching element, arranged two-dimensionally, and
5 having a pixel sequence in which the switching elements are connected to a common line, the method comprising the steps of: applying a control signal for driving the switching elements at the same time from at least two different points of the common line; and driving the switching elements which
10 is connected to the common line in accordance with the control signal applied to the common line.

In a fifth aspect, the present invention provides an image input apparatus comprising: an area sensor having plural pixels arranged therein two-dimensionally, each pixel having a thin-film transistor and a photoelectric conversion element, having plural common gate lines which are connected to the gate electrodes of the thin-film transistors arrayed in one direction and plural common lines which are connected to the source or drain electrodes of the thin-film
15 transistors arrayed in another direction, having plural signal reading means connected to the common lines, having plural gate driving means connected to the common lines, and having a wavelength conversion member in the photoelectric conversion element; an electromagnetic-wave generation
20 source; image processing means for processing an image
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signal from the area sensor; and display means for displaying an image on which image processing is performed.

According to the present invention having such a construction, it is possible to eliminate impairment, such as the entirety of one line being incapable of being driven due to a disconnection. Furthermore, it is possible to provide an area sensor which can be driven at a higher speed.

Furthermore, according to the present invention, it is possible to read image information at a higher definition.

In addition, according to the present invention, since driving at a higher speed becomes possible, it is possible to capture a moving image. As a result, when X-ray transmitted images are to be read, it is possible to continuously observe the motion of an object in real time.

Therefore, not only is the operation efficiency significantly improved, but also during medical or structural analyses, and during security checks, the examination time can be reduced and the examination system can be further improved, thus making more precise decisions and diagnoses possible.

In the present invention, a photoelectric conversion element is provided in a common manner or is provided individually in each pixel. In a case in which the pixels are provided in a common manner, it is preferable that the photoelectric conversion information thereof be adjusted so

as not to generate crosstalk for each pixel. For the photoelectric conversion element, it is preferable that an amorphous semiconductor, for example, amorphous silicon, be used for a larger area. For the photoelectric conversion 5 element, any of a diode type, photoconductive type, or transistor type may be used.

It is a matter of course that the photoelectric conversion element is not limited to these structures. An MIS (metal-insulation-silicon)-type structure in which the 10 capacitor structure and the photoelectric conversion element are integrated may be used. In such a case, it is possible to read the photoelectrically converted image information in a nondestructive manner, and it is possible to substantially 15 adjust the sensitivity by adjusting the storage time by the adjustment of the photoelectric conversion period.

Alternatively, since electromagnetic waves such as X rays enable direct photoelectric conversion, it is possible to use amorphous selenium, lead(II) iodide (PbI_2), and gallium arsenide in the photoelectric conversion section.

20 The gate driving means and the signal reading means of the area sensor may be connected to the common gate line or the common source line by, for example, an anisotropic connection which is a wiring connection using an anisotropic conductive resin. This makes it possible to reduce the time 25 and effort required to manufacture the area sensor when a

larger area is to be provided.

As switching elements, thin-film transistors may be preferably used.

The above and further objects, aspects and novel features of the invention will become more fully apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic circuit diagram of an example of an area sensor having a photoelectric conversion element and a switching element in a pixel;

Fig. 2A is an equivalent circuit diagram of a gate line of the area sensor;

Figs. 2B and 2C are conceptual diagrams of a driving waveform (gate pulse) at each point;

Fig. 3 is a timing chart illustrating an example of the driving of a gate driver in the area sensor;

Fig. 4 is a schematic circuit diagram illustrating an example of an area sensor;

Figs. 5A and 5B are timing charts illustrating an example of the operation of the area sensor;

Fig. 6 is a schematic circuit diagram illustrating an example of an area sensor;

Fig. 7 is a schematic circuit diagram of an example of

the construction of a photoelectric-conversion-element panel section, which is an area sensor;

Figs. 8, 9, and 10 are each a conceptual circuit diagram illustrating the circuit construction of a reading apparatus part;

Fig. 11 is a system configuration diagram illustrating an application example of an image input apparatus;

Fig. 12 is a schematic diagram of the image input apparatus; and

Fig. 13 is a schematic sectional view illustrating an example of an area sensor pixel part.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention are described below with reference to the accompanying drawings.

<First Embodiment>

Fig. 4 is a schematic circuit diagram illustrating an example of an area sensor of the present invention.

Components in Fig. 4 which are the same as those in Fig. 1 are given the same reference numerals. Figs. 5A and 5B are each a timing chart illustrating an example of the operation of the area sensor in the first embodiment.

Similarly to that in the example shown in Fig. 1, each pixel S of the area sensor is formed of a photodiode PD and a thin-film transistor (TFT) Tr. The cathode electrode of

the photodiode PD is connected to a bias line Vs, and a bias voltage is applied thereto by a power supply 3. The source electrodes of the thin-film transistors Tr are connected to the data lines Sig1 to SigN for each pixel column. The gate 5 electrodes of the thin-film transistors Tr are connected to the gate lines Vg1 to VgN for each pixel row. The anode electrodes of the photodiode PD and the drain electrodes of the thin-film transistors Tr are connected to each other by pixels. Furthermore, each of the data lines Sig1 to SigN is connected to a reading apparatus 1 comprising an amplifier 1a and an analog multiplexer 1b. The point to be noted herein is that each of the gate lines Vg1 to VgN is connected to both a first gate driver 2 comprising a shift register and a second gate driver 6 disposed so as to oppose a side in which the gate driver 2 is disposed.

Figs. 5A and 5B each show a timing chart of a gate pulse which is applied to the gate lines Vg1 to VgN by the first gate driver 2 and the second gate driver 6 in Fig. 4, respectively. As is clear from Figs. 4, 5A, and 5B, in this embodiment, each of the gate lines Vg1 to VgN is connected to the first gate driver 2 and the second gate driver 6, and a gate pulse of the same pulse width is applied at the same time by the two gate drivers.

The driving timings of the two gate drivers can be

25 synchronized by inputting the driving start signals (start

signals) of the two gate drivers at the same time. It is of course more preferable that the driving be controlled in accordance with a common clock signal. The gate driver is provided with a start signal input section for receiving a 5 driving start signal (start signal) so as to start driving.

With this construction, even if a disconnection occurs in the gate line, it is possible to apply a gate pulse from either one of the gate drivers. As a result, such a problem, as transferring of a signal from a pixel connected to the 10 gate line cannot be performed and reading of image information becomes impaired, which is caused by a disconnection of the gate line, does not occur.

Furthermore, since a gate pulse is applied to each gate line at the same time, the resistance and the parasitic 15 capacitance of the gate line are reduced substantially, and a delay in the gate pulse is reduced, thereby making higher-speed driving possible.

Examples of metal materials used for gate lines of the area sensor of the present invention, and examples of 20 electric resistivity in a case where each is formed into a film are shown in Table 1 below.

Table 1

Metal	Resistivity ($\mu\Omega \cdot \text{cm}$)
Cr	50
Ti	200
Mo	50
Mo-Ta	50

As can be seen from this Table, when chromium is used
5 as the metal material for the gate line, the film thickness
is set to 1000Å, the wiring width is set to 10 μm , and the
line length is set to 20 cm, the gate line resistance, that
is, R_{vg} , reaches 100 k Ω . That is, in a case where chromium,
titanium, molybdenum, a molybdenum-tantalum alloy, etc., is
10 used for the wiring of the gate line, generally, the wiring
resistance R_{vg} becomes several tens to hundreds of k Ω .

Also, there are cases in which the parasitic
capacitance C_{vg} of the gate line generally becomes several
tens to several hundreds of pF, and the time constant by R_{vg}
15 and C_{vg} becomes several μs .

This cannot be ignored in view of higher speed because,
for example, when the total number of gate lines is 1000,
the delay time becomes several milliseconds in total.
However, as a result of forming the construction of the
20 present invention, each of R_{vg} and C_{vg} can be substantially
reduced to 1/2, and the time constant is reduced to 1/4.

Therefore, the present invention is particularly effective for a case in which the resistivity exceeds 10 $\mu\Omega \cdot \text{cm}$, such as when chromium, titanium, molybdenum, a molybdenum-tantalum alloy, etc., is used for the material of 5 the metal wiring.

As shown in Fig. 15, in order that a TFT be turned on and electric charge be transferred, a fixed time period T_b or more is necessary. As shown in Figs. 14A and 14B, this time period T_b is determined by a time constant τ_1 which is 10 a product of the capacitance C_{pd} and the on-resistance R_{on} of the TFT of the photoelectric conversion element PD. Fig. 14A shows a pixel and a reading device, and Fig. 14B shows an equivalent circuit for charge transfer.

On the other hand, the rounding of the pulse waveform 15 of the gate line, such as that shown at C in Fig. 15, is determined by a time constant τ_2 which is a product of the resistance R_{vg} and the parasitic capacitance C_{vg} of the gate line V_g . In this embodiment, it is preferable that a gate pulse be applied from both ends of the gate line, and the 20 following relation be satisfied:

$$\tau_1 \geq \tau_2$$

That is, as a result of realizing the relation of $\tau_1 \geq \tau_2$ in this manner, it is possible to substantially prevent 25 the rounding of the gate pulse from exerting a large influence on the overall speed.

Rvg described herein can be determined by measuring the resistance across both ends (point A and point B in Fig. 15) of the gate line. Also, Cvg is a lumped-constant-related parasitic capacitance of the gate line. When Cvg and Rvg
5 cannot be directly measured, as shown in Fig. 15, it is possible to observe the waveform of the gate pulse at the center (point C) of the gate line and to determine the time constant τ_2 therefrom.

Furthermore, the present invention is effective in
10 reducing noise. That is, thermal noise corresponding to the resistance occurs in the gate line. Furthermore, as shown in Fig. 15, the gate line Vg and the data line Sig are capacitively coupled. This shows that the thermal noise of the gate line propagates to the data line via the capacitive
15 coupling, causing random noise. In the present invention, Rvg is substantially reduced by driving the gate line from both sides. That is, the influence of the thermal noise arising from Rvg is reduced.

<Second Embodiment>

20 Fig. 6 is a schematic circuit diagrams illustrating another example of an area sensor of the present invention. Components in Fig. 6 which are the same as those in Fig. 1 are given the same reference numerals.

25 Also in this embodiment, in a manner similar to the above-described first embodiment, each of the gate lines Vg1

to VgN of the area sensor is connected at its one end to the first gate driver 2 and is connected at the opposing other end to the second gate driver 6. As described in Figs. 5A and 5B, a gate pulse is applied from the two gate drivers 2 5 and 6 at the same time.

Furthermore, in this embodiment, in addition to the gate lines Vg1 to VgN, each of the data lines Sig1 to SigN is connected at its one end to the first reading apparatus 1 and is connected at the opposing other end to a second 10 reading apparatus 8. The second reading apparatus 8 comprises an amplifier 8a and an analog multiplexer 8b in a manner similar to the first reading apparatus 1.

Data which are read through data lines and which are photoelectrically converted by pixels are output to the 15 respective analog multiplexers via the amplifier 1a and the amplifier 8a.

With such a connection construction, even if a disconnection occurs in the gate line or the data line, since a signal can be supplied and read, impairment due to a 20 disconnection does not occur. That is, in a case where a disconnection occurs in the data line, the data from the pixel in Fig. 6 in a portion after the disconnection can be read from the first reading apparatus 1, and the data from the pixels in a portion before the disconnection can be read 25 from the second reading apparatus 8. The reading timing of

the first reading apparatus 1 may be the same as or may be different from the reading timing of the second reading apparatus 8.

Since the resistance and the parasitic capacitance can
5 be decreased substantially by performing the driving of the gate lines at the same time as described in the first embodiment, high-speed driving is made possible.

Furthermore, when the gate line is disconnected, a driving signal is supplied from any one of the gate drivers, and therefore, a problem as a result of a disconnection in the gate line does not occur.

<Third Embodiment>

Fig. 7 is a schematic diagram showing an example of the construction of a photoelectric-conversion-element panel section, which is an area sensor, provided within an X-ray photographing apparatus of an X-ray photographing system.

In the photoelectric-conversion-element panel, pixels SE having a pair of photoelectric conversion element and thin-film transistor for transferring electric charge are formed in an arrayed form on a substrate in which at least the surface thereof has insulating properties, such as a glass substrate. For a signal which carries image information from each pixel, a group of pixels arrayed two-dimensionally is divided into two right and left areas in Fig. 7, and a plurality of common signal lines (data lines)

are extended to the right and left for each area.

In Fig. 7, a plurality of common gate lines (gate lines) are provided in the vertical direction, and two shift registers (serving as gate drivers) for driving gates are connected to the upper and lower end portions of each common gate line. The shift registers disposed in the upper and lower portions are driven at the same timing by a control circuit (not shown) and operate so as to apply a coincidence gate pulse to one gate line.

In this embodiment, the gate lines are divided into a pixel group which is divided into two groups, and are formed of a group of gate lines (1 to 1440) corresponding to the group of pixels in the left half in the figure and a group of gate lines (1441 to 2880) corresponding to the group of pixels in the right half. One gate line is selected from each group of gate lines, and a gate pulse is supplied thereto. Therefore, when seen in the entirety of the photoelectric conversion panel, the construction is formed in such a way that a gate pulse is applied to two gate lines at the same time, and the electric charge transferred thereby can be processed simultaneously by two sets on the right and left of an amplifier and multiplexer group (serving as a reading apparatus) formed of a circuit having an amplifier and multiplexer group.

With this construction, only a half time is required to

read the entire surface of the panel, and the length and the capacity of the common signal line can be substantially reduced by a half. Therefore, it is possible to construct an X-ray photographing system with a high sensitivity, which 5 is capable of performing high-speed reading with a small amount of noise.

One shift register is formed of, for example, six ICs (240bit/IC). In the surrounding of the image receiving area, that is, in an upper right portion, an upper left portion, a lower right portion, and a lower left portion in the figure, a shift register is provided, and a total of four shift registers are disposed. Therefore, a total of 24 ICs used in the shift registers are disposed in the surrounding.

The reading apparatus, in practice, has an amplifier IC 15 in which the functions of both an amplifier and a multiplexer are integrated. Nine amplifier ICs (a total of 18) are disposed in each of the right and left to the image pickup area. Amplifier ICs (AmpIC) (256Amp/IC) are provided so as to correspond to the 256 data lines. For the 20 amplifier IC in the embodiment, a current-integrating-type is used. Furthermore, the portion (the portion of the reading apparatus) of a group of amplifier ICs having an amplifier and a multiplexer, indicated by C in the figure, may be, for example, of three connection types such as those 25 described below.

Examples of schematic circuit constructions of the three types are shown in Figs. 8, 9 and 10.

Fig. 8 shows that the outputs of nine amplifier ICs are connected to one and is input to one A/D conversion circuit.

5 The output of each amplifier IC is controlled in accordance with an IC select signal, and the output of any one of the amplifier ICs is input to the A/D conversion circuit. The analog output which is input to the A/D conversion circuit is converted into a digital signal thereby and is output.

10 Herein, although a plurality of amplifier ICs are used, one large multiplexer (2260 inputs and 1 output) is formed as a whole.

Next, the circuit construction shown in Fig. 9 is described. Herein, data lines for transferring a sensor signal are connected to each of the amplifiers which are divided into an odd-number group and an even-number group of the data lines. The output from each amplifier is sent to an analog multiplexer corresponding to amplifiers (or data lines) of the odd-number group and the even-number group through a sample-and-hold circuit in a manner similar to the circuit construction shown in Fig. 8. Therefore, the amplifier ICs having an amplifier and a multiplexer are disposed so as to correspond to the odd number or the even number of the data lines, and two analog signals of the 20 output of the odd-number group and the output of the even-

number group are output from the amplifier ICs independently of each other. The output of the odd-number group and the output of the even-number group are connected so as to be input to the A/D conversion circuits corresponding to the 5 odd number and the even number, respectively.

As a result, in the construction shown in Fig. 9, in the amplifier ICs of the odd-number group and the amplifier ICs of the even-number group, two types of multiplexers corresponding to the odd-number group and the even-number 10 group are formed. The digital outputs from the respective A/D conversion circuits corresponding to the odd number and the even number are combined by a digital multiplexer and is output as one continuous digital signal.

In Fig. 10, in a manner similar to that in Fig. 9, two 15 analog signals separated for the odd-number group and the even-number group are output from the amplifier ICs. Here, the analog outputs corresponding to the even-number group and the odd-number group are input to one analog multiplexer (2 inputs and 1 output), whereby one analog output is 20 obtained. This is considered in such a way that one large multiplexer (2260 inputs and 1 output) is formed in a manner similar to that in Fig. 8. The analog output from the analog multiplexer is input to the A/D conversion circuit, whereby it is converted into a digital output and is output 25 as a signal.

Fig. 11 shows an example in which an image input apparatus having the area sensor shown in Fig. 7 is applied to an X-ray photographing system. Fig. 12 shows an example of a case in which X rays of an X-ray photographing apparatus using an area sensor are wavelength-converted into a wavelength which can be detected by the area sensor.

Fig. 11 is a diagram showing an example of the application of an X-ray photographing apparatus using an area sensor of the present invention into an X-ray photographing system.

X rays 6060 which are generated in an X-ray tube 6050 as an electromagnetic-wave generation source is transmitted through an observed portion 6062, such as the chest of a patient or subject 6061, and enters an area sensor (photoelectric conversion device) 6040 having mounted in the upper portion thereof a scintillator as a wavelength conversion member. These incident X rays contain information of the interior of the subject 6061. In response to the incidence of the X rays, the scintillator emits light. This is photoelectrically converted to obtain electrical information. This information is converted into digital form, image processing is performed thereon by an image processor 6070, and this can be observed by a display 6080 in a control room.

Furthermore, this information can be transferred to a

distant place by transmission means, such as a telephone line or wireless 6090, and it is possible for a doctor at a remote location to perform diagnosis by using a display on a display 6081 or by using an output on a film at a doctor 5 room of another place. The obtained information can also be recorded or stored in a recording medium using various types of recording materials, such as an optical disk, an magneto-optical disk, or a magnetic disk, and a recording medium 6110, such as a film or paper, by recording means 6100, such 10 as a film processor.

The above-described X-ray photographing apparatus is not particularly limited to that for medical purposes and can also be used in applications, such as nondestructive examinations, etc.

15 In the X-ray photographing apparatus used for nondestructive examinations, such as medical diagnoses and interior examinations, a subject, such as a human body, is irradiated with X rays, and the X rays which are transmitted through the subject are converted by a wavelength conversion 20 member, such as a fluorescent member, into light which can be detected by an area sensor, and the light is irradiated to a photoelectric conversion section, such as a photoelectric conversion device so that the light is converted into an electrical signal which carries image 25 information.

Fig. 12 is a schematic diagram showing an example of such an X-ray photographing apparatus. In Fig. 12, reference numeral 501 denotes an X-ray source. Reference numeral 502 denotes a subject, such as a human body (patient), with which the X rays emitted from the X-ray source 501 are irradiated. Reference numeral 503 denotes a grid, in which substances which absorb X rays and substances through which X rays are transmitted are alternately disposed, for removing the scattered X-ray components and improving the resolution. Reference numeral 504 denotes a wavelength conversion member which is provided so that the irradiated electromagnetic wave is converted in wavelength to light of a wavelength which can be sensed by the photoelectric conversion element. Normally, for this member, a scintillator which absorbs X rays and which emits light of a wavelength which can be photoelectrically converted by the photoelectric conversion element is used, and more specifically, fluorescent substances, such as CsI (cesium iodide) or Gd₂O₂S, may preferably be used. Reference numeral 505 denotes an area sensor for receiving light from the wavelength conversion member 504. The area sensor of the present invention can be applied to this part.

Regarding the construction of the area sensor, as described above, an area sensor in which photoelectric conversion elements are arranged in a matrix, which is

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commonly known, can be used. For example, an area sensor having a construction such as that disclosed in, for example, Japanese Unexamined Patent Application Publication No. 8-116044, may be used.

5 For example, as shown in Fig. 13, a photoelectric conversion element S11 having a first electrode 1301, an insulation layer 1302, a photoconductive layer 1303 such as amorphous silicon, an ohmic contact layer 1304, and an electrode layer 1305 in this order on a substrate 1310, such as glass, in which at least the surface thereof has insulating properties has a construction in which each layer is multilayered in the same order as that of a thin-film transistor element (TFT) T11. Therefore, these elements can be formed on one substrate at the same time. The first 10 electrode 1301 of the photoelectric conversion element S11 is used for the gate electrode of the TFT, the insulation layer 1302 is used for the gate insulation film, the photoconductive layer 1303 is used for a semiconductor layer, the ohmic contact layer 1304 such as an n⁺ layer is used for 15 an ohmic contact layer, and the electrode layer 1305 is used for a source or drain electrode.

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Furthermore, in Fig. 13, reference numeral 1306 denotes a protective layer such as silicon nitride (SiN), and reference numeral 1307 denotes a wavelength conversion 25 member such as cesium iodide (CsI). Reference letters SIG

denote a data line.

A case in which pixels are formed by elements of the same multilayered construction such as that described above is effective in the formation of a large area of the image receiving area and in the reduction of manufacturing costs. Furthermore, in the photoelectric conversion element of the above-described construction, when X rays having image information enter, electric charge corresponding thereto is generated, and the electric charge can be stored in the element, it is also possible to read the information in a nondestructive manner, and this is preferable in that it is possible to deal with a variety of variations of driving methods.

As has thus been described, according to the present invention, it is possible to provide a highly reliable area sensor in which there is no defective driving such as that which occurs due to a disconnection of wiring which crosses an image receiving area such as gate lines and data lines, and in which there is no impairment such as inability to obtain data, and in which image information can be output stably, to provide an image input apparatus having the area sensor, and to provide a method of driving the area sensor.

Furthermore, according to the present invention, it is possible to realize an area sensor which can be driven at high speed because a desired driving waveform can be

supplied, and as a result which is suitable for obtaining a moving image, to realize an image input apparatus having the area sensor, and to realize a method of driving the area sensor.

5 In addition, according to the present invention, it is possible to provide an area sensor having an image receiving area which is larger, an image input apparatus having the area sensor, and a method of driving the area sensor, and to provide an area sensor, in which a driving speed is not decreased due to the larger area, or in which driving speed can be improved, the decrease in the driving speed being minimized in comparison with a case in which area sensors having an image receiving section of a small area are combined, and higher definition reading and display being made possible, to provide an image input apparatus having the area sensor, and to provide a method of driving the area sensor.

According to the present invention, since the signal reading means comprises an amplifier IC having an amplifier provided individually for each data line, and an analog multiplexer; and an A/D converter, it is possible to realize an area sensor capable of reading a signal at high speed and with high accuracy.

According to the present invention, since the output of each amplifier IC can be selected and controlled in

accordance with a select signal, it is possible to realize an area sensor capable of reading a signal at a desired sequence.

According to the present invention, since the outputs 5 of each amplifier IC are formed differently for the even-number group and the odd-number group, it is possible to realize an area sensor capable of reading a signal at a higher speed.

According to the present invention, since the outputs 10 of each amplifier IC are formed differently for the even-number group and the odd-number group so as to perform a multiplexing operation (selection operation), it is possible to realize an area sensor in which the rearrangement of signals is not necessary and image processing is easy.

15 In addition, according to the present invention, it is possible to reduce random noise arising from the wiring resistance of the gate line and to realize a higher S/N ratio.

Many different embodiments of the present invention may 20 be constructed without departing from the spirit and scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in this specification. To the contrary, the present invention is intended to cover various modifications 25 and equivalent arrangements included within the spirit and

scope of the invention as hereafter claimed. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications, equivalent structures and functions.